THE LIFETIME OF HYPERFRAGMENTS*

G. C. DEKA

DEPARTMENT OF PHYSICS, COTTON COLLEGE, GAUHATI

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ABSTRACT. Available data on the time of flight of hyperfragments have been used to deduce a lifetime for light hypernuclei, and the value thus obtained is discussed.

During recent years a large number of nuclear fragments, so-called hyperfragments (HF) which contain a Λ° hyperon have been observed in nuclear emulsions and their proper analysis has also been made. Along with other properties the Λ° hyperon binding energy of most of the low charged ($Z \leqslant 3$) HFs have been measured. An extensive search on the subject was also made by the author (Thesis 1959), and the results have been published in Nuovo Cimento (1959). A detailed survey of the available data was reported by Levi-Setti *et al.* (1958). An interesting aspect of the subject which is not yet attempted by any previous worker is the measurement of the lifetime of such HFs and a comparison with that of a free Λ° hyperon decay. The latter is however fairly well known from different chamber experiments. Several authors using statistical procedures have estimated the mean lifetime of the free Λ° particle. A value reported by Blumenfield *et al.* (1956) is $2.8 \pm .4 \,.\, 10^{-10}$ sec obtained on the basis of 65 events observed in a 36″ multiplate cloud chamber exposed to a π-meson beam at Brookhaven. A recent value quoted by Raman (1960) in his book is $2.6 \pm .16 \,.\, 10^{-10}$ sec which includes data upto 1959.

When measuring the lifetime of HFs there are a number of experimental difficulties e.g.

i) Most of the HFs decay at rest permitting thereby only the measure of moderation time which is a lower estimate of the mean life.

ii) Decays in flight which yield information about the mean life are difficult to detect and identify due to the similar events recorded in emulsions.

iii) Non mesonic decays are very often missed in observations.

iv) Heavy HFs, which are usually short evaporation tracks, cannot be identified nor their velocity at production can be calculated.

The experiments made and the procedures adopted by the author are briefly as follows :

*The preliminary result of this paper was reported in the Cosmic Ray symposium held at Ahmedabad, 1960.

A stack of Ilford G5 emulsions exposed to an intense beam of 4.5 BeV π^- mesons from Berkeley Bevatron was area scanned under low magnification. All double stars which may be possible HFs were picked up. Another stack of K5 emulsions exposed to a beam of 300 MeV/c K$^-$-mesons from the same machine was line scanned for double stars. All the secondary particles emitted from the second stars were followed to their ends, and their energy and mometum were determined from the observed ranges.

Out of 51,000 pion interactions 98 double stars and of 1300 K$^-$ interactions at rest 61 double stars were picked up and analysed by applying a few selection criteria in order to minimise the bias, arising out of similar events like nuclear collisions, captures of negatively charged particles and chance coincidences.

The interconnecting track of every star was closely examined for its multiple scatterings and the thinning down near the second star, the features which usually indicate the stopping of a particle. For a flat interconnector of range $\geqslant 20\mu$ it may be possible to exclude π^- meson-capture, as the high multiple scatterings of such a track is distinctive. In a very few cases the charge Z of the HF could also be determined from δ-ray observation or by profile measurements on the tracks. The non mesonic decays in flight of heavy HFs were indicated by the presence of δ-rays closed to the second star. Sometimes the mass of a long ranged HF can be determined from multiple scatterings by a constant sagitta method. To define a HF decay the information from the detailed analysis of the second star was taken. A HF which decays into two charged particles producing two collinear tracks or, into three charged particles producing three co-planar tracks could be uniquely defined. Others, for which are obtained a sensible Λ-binding energy when the unbalanced momentum is given to one neutron only, are also considered to be nearly unique. Besides, there are a number of events which

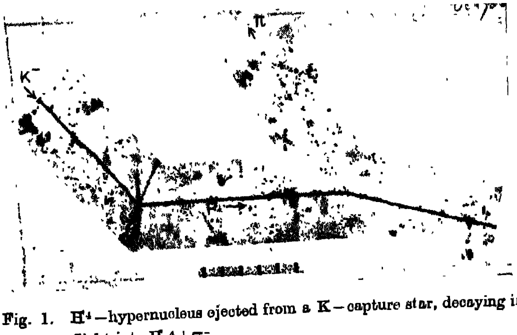

Fig. 1. H^4—hypernucleus ejected from a K—capture star, decaying in flight into $H_e{}^4+\pi^-$.

cannot be interpreted from such analysis, but may not show any feature which can exclude them from being HF decay.

The time of flight or the moderation time of the well defined HFs are determined from their observed range by using the recent range-energy relations given by Barkas (1957).

Two HF decays in flight have been reproduced in Figs. 1 and 2.

Fig. 2. $B^{10,11}$ —hypernucleus ejected from a 4.5 BeV π^- meson decaying in flight into He^4+p+n (2).

The available data has been listed in the Tables I and II

TABLE I

Events observed by the author

	HFs	No. of events observed		Total time of flight in 10^{-10} sec.
		At rest	In flight	
Mesonic decays	H^4	4	1	0.64
	He^4	4		0.07
	He^5	6		1.50
	Li^7	1		0.04
	Be^8	1		0.07
Non-mesonic decays	He^4	1	...	0.08
	$Li^{6,7}$	...	1	0.18
	$B^{10,11}$	...	1	0.03

TABLE II

Events observed by other authors

	HFs	Time of flight in 10^{-10} sec.	Reference
Mesonic decays	H^3 (f)	1.30	Friedlander *et al.*, 1956.
	H^3 (,,)	0 06	Filipkiwski, *et al.*, 1958.
	H^4 ,,	0.22	–do–
	He^4 ,,	0 77	Fowler and Hansen, 1956.
	H^3 ,,	1 10	Cloud Chamber expt.
	He^4 ,,	5 00	–do–
	H^3 ,,	0.02	Sorensen, *et al.*, 1956.
	He^4 ,,	5.40	Sorrel, *et al.*, 1955.
	H^3 (r)	1.30	Castognoli, *et al.*, 1955.
	H^3 ,,	0.45	Herman Yagoda. 1955.
	H^3 ,,	0 15	Imaeda, *et al.*, 1958.
	H^3 ,,	0 15	–do–
	H^3 ,,	0 22	–do–
	He^5 ,,	0 50	Hill, *et al.*, 1956.
	Li^7 ,,	1 00	Filipkowski, *et al.*, 1956.
Non-mesonic decays	H^4 (f)	0 11	Fry, *et al.*, 1958.
	Be (r)	0 11	Castognoli, *et al.*, 1955.
	B ,,	0.76	–do–

Ignoring the biases against detecting decays in flight and the non mesonic decays, a life time has been deduced from the above data. Such values are the following :

(1) $2.7 \pm 0.9 \times 10^{-10}$ sec for the mesonic decay,

(2) $0.4 \pm 0.2 \times ^{-10}$ sec for the non-mesonic decay.

This shows that there is little difference between the lifetime for HFs decaying mesonically and that for a free Λ^0 decay. The much lower value for the non-mesonic decay is apparently due to the considerably fewer events.

It is however to remark that as the experimental materials may contain bias and the events cannot be selected in controlled conditions the above results cannot therefore be given an unambiguous physical interpretation. It is more an indication of the interest to collect data in a well controlled unbiased manner.

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